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Faltyn et al.

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(54) **SECURE MOBILE FRAMEWORK**

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(51) **Int. Cl.**
G06F 17/30 (2006.01)
G06F 21/00 (2013.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04L 63/20*** (2013.01); ***H04L 63/08*** (2013.01); ***H04W 12/06*** (2013.01); ***H04W 12/08*** (2013.01)

(58) **Field of Classification Search**
CPC H04L 63/10; H04L 63/20; H04L 63/102; H04L 67/10; H04L 67/34; G06F 17/30; G06F 21/00; G06F 21/30; G06F 21/41; G06F 21/60; G06F 21/604; G06F 21/629
USPC 709/203, 225, 229; 726/1, 2, 3, 27
See application file for complete search history.

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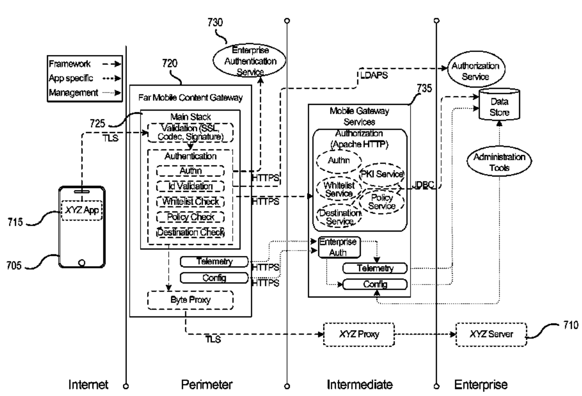
Assistant Examiner — Kalish Bell
(74) *Attorney, Agent, or Firm* — Synchronoss Technologies, Inc.; Frederick W. Dour

(57) **ABSTRACT**

Systems and methods for a secure mobile framework to securely connect applications running on mobile devices to services within an enterprise are provided. Various embodiments provide mechanisms of securitizing data and communication between mobile devices and end point services accessed from a gateway of responsible authorization, authentication, anomaly detection, fraud detection, and policy management. Some embodiments provide for the integration of server and client side security mechanisms, binding of a user/application/device to an endpoint service along with multiple encryption mechanisms. For example, the secure mobile framework provides a secure container on the mobile device, secure files, a virtual file system partition, a multiple level authentication approach (e.g., to access a secure container on the mobile device and to access enterprise services), and a server side fraud detection system.

23 Claims, 10 Drawing Sheets



(51) **Int. Cl.**

G06F 21/41	(2013.01)
H04L 29/06	(2006.01)
H04W 12/08	(2009.01)
H04W 12/06	(2009.01)

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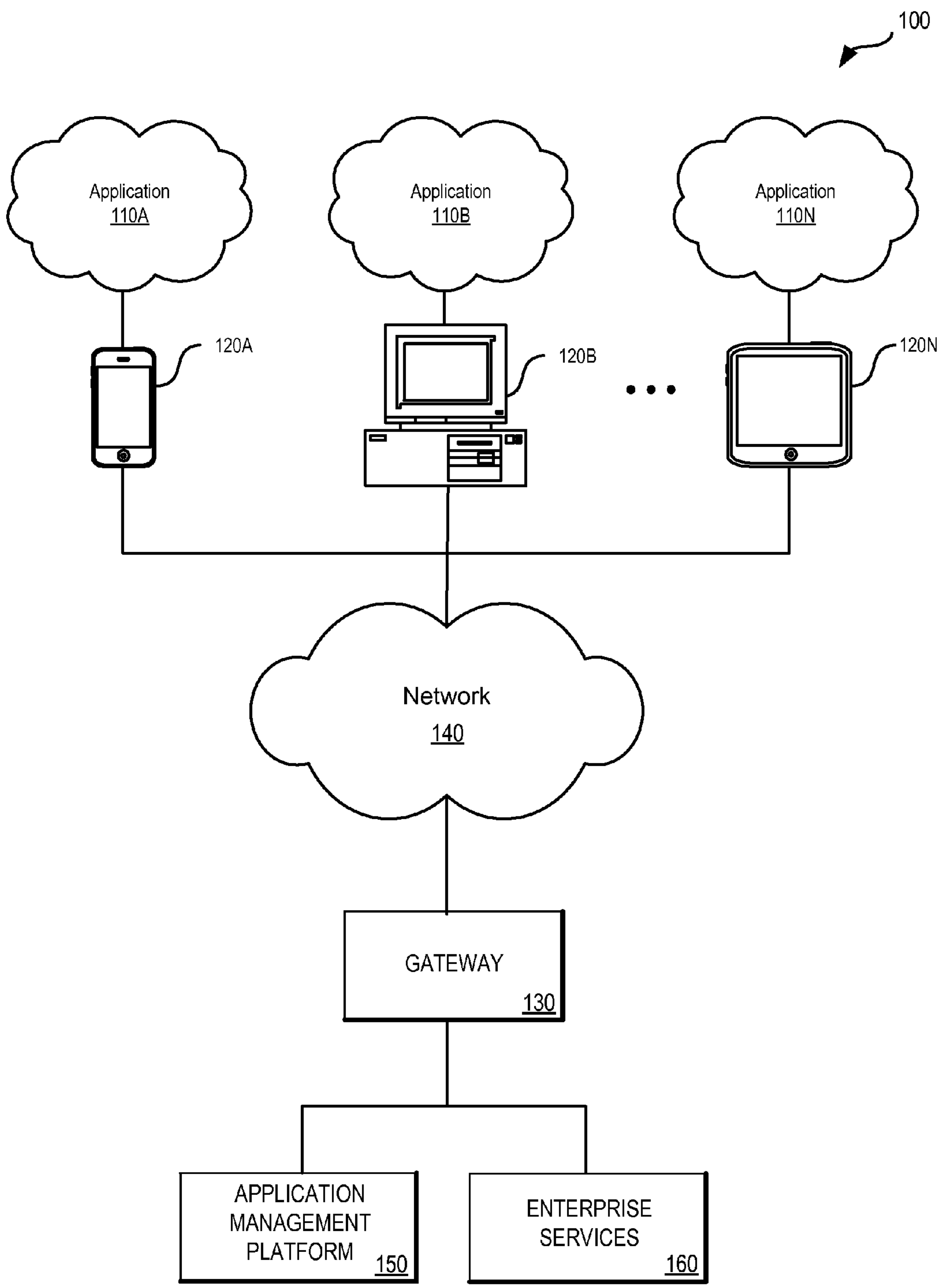

100
Application
110A
Application
110B
Application
110N
120A
120B
120N
Network
140
GATEWAY
130
APPLICATION
MANAGEMENT
PLATFORM
150
ENTERPRISE
SERVICES
160

FIG. 1

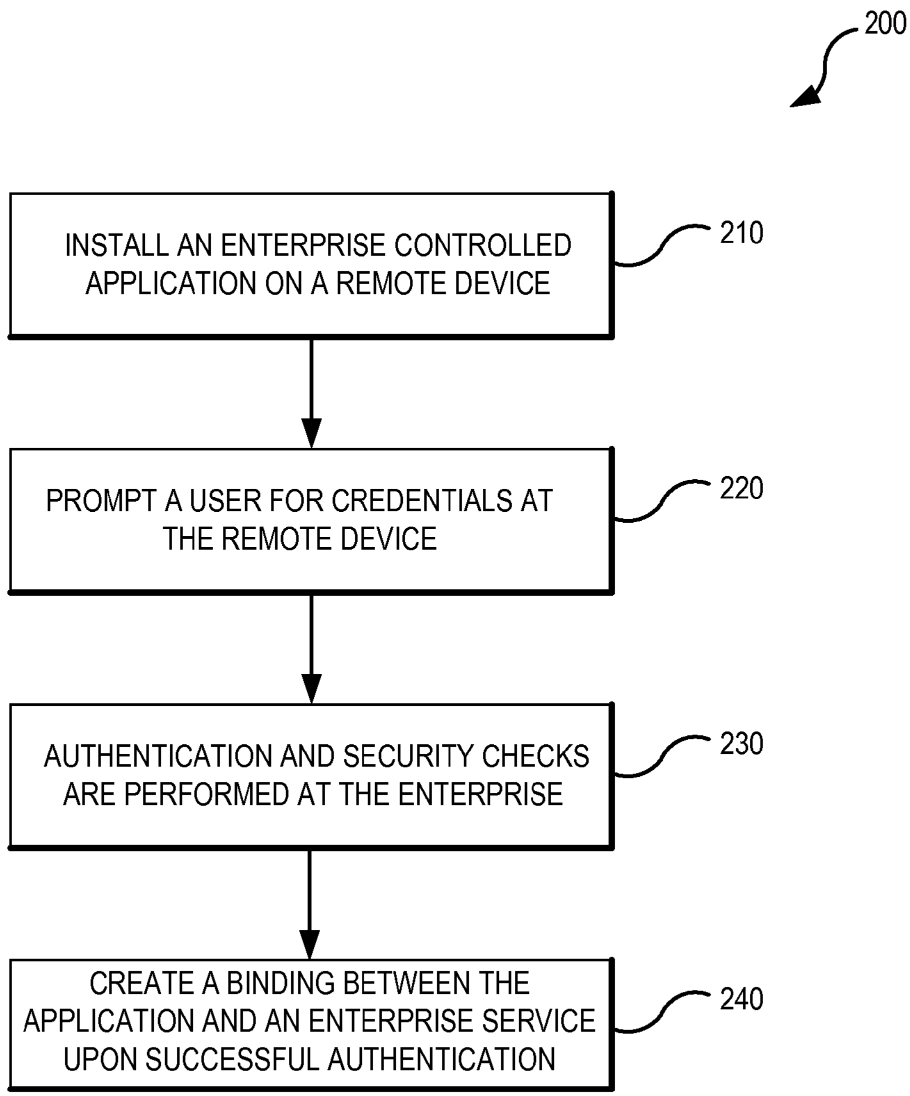

200
INSTALL AN ENTERPRISE CONTROLLED APPLICATION ON A REMOTE DEVICE
210
PROMPT A USER FOR CREDENTIALS AT THE REMOTE DEVICE
220
AUTHENTICATION AND SECURITY CHECKS ARE PERFORMED AT THE ENTERPRISE
230
CREATE A BINDING BETWEEN THE APPLICATION AND AN ENTERPRISE SERVICE UPON SUCCESSFUL AUTHENTICATION
240

FIG. 2

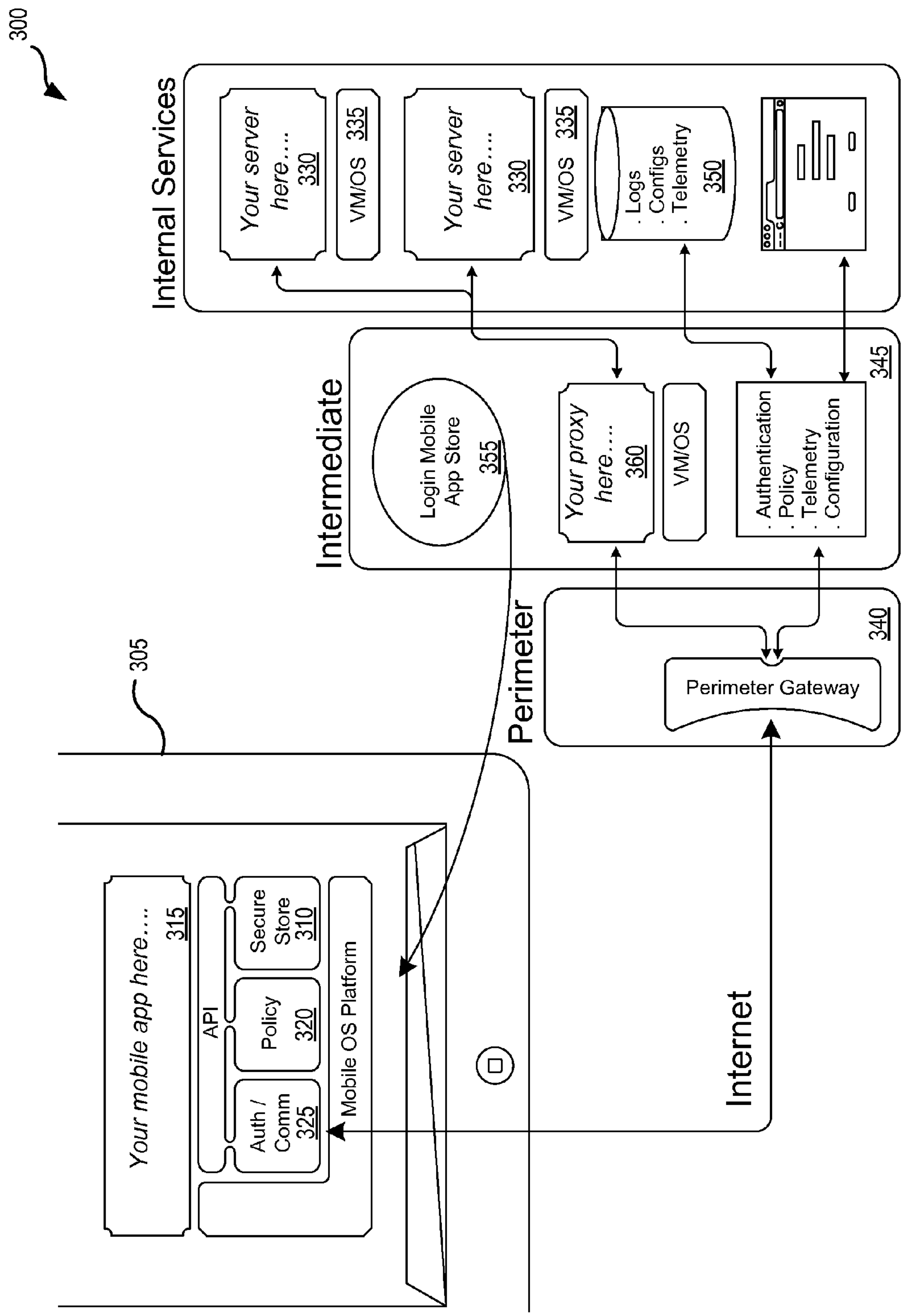

300
305
Internal Services
Your server here.... 330
VM/OS 335
Your server here.... 330
VM/OS 335
. Logs
. Configs
. Telemetry
350
Intermediate
Login Mobile App Store 355
Your proxy here.... 360
VM/OS
. Authentication
. Policy
. Telemetry
. Configuration
345
Perimeter
Perimeter Gateway
340
Your mobile app here.... 315
API
Secure Store 310
Policy 320
Auth / Comm 325
Mobile OS Platform
Internet

FIG. 3

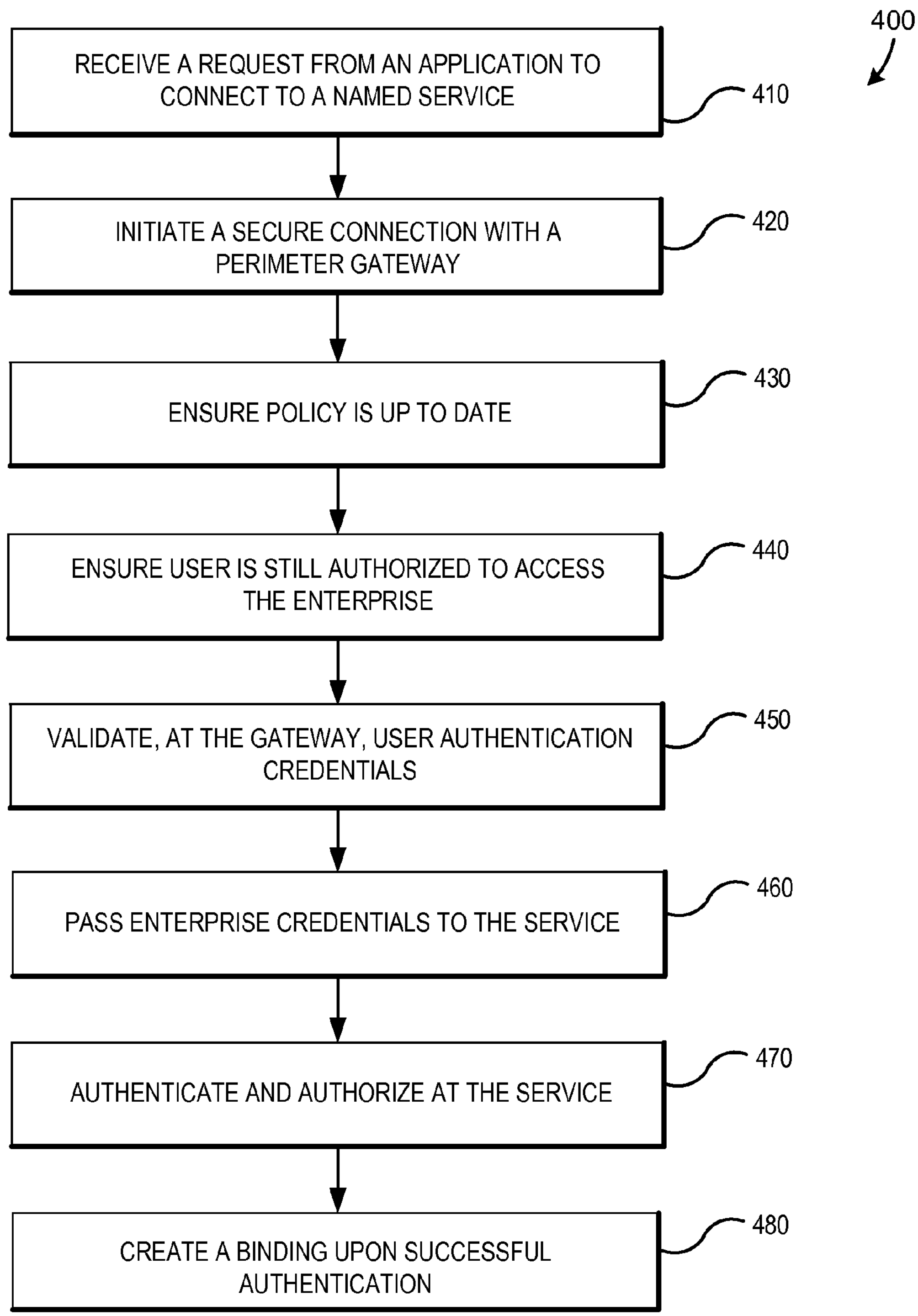

400
RECEIVE A REQUEST FROM AN APPLICATION TO CONNECT TO A NAMED SERVICE
410
INITIATE A SECURE CONNECTION WITH A PERIMETER GATEWAY
420
ENSURE POLICY IS UP TO DATE
430
ENSURE USER IS STILL AUTHORIZED TO ACCESS THE ENTERPRISE
440
VALIDATE, AT THE GATEWAY, USER AUTHENTICATION CREDENTIALS
450
PASS ENTERPRISE CREDENTIALS TO THE SERVICE
460
AUTHENTICATE AND AUTHORIZE AT THE SERVICE
470
CREATE A BINDING UPON SUCCESSFUL AUTHENTICATION
480

FIG. 4

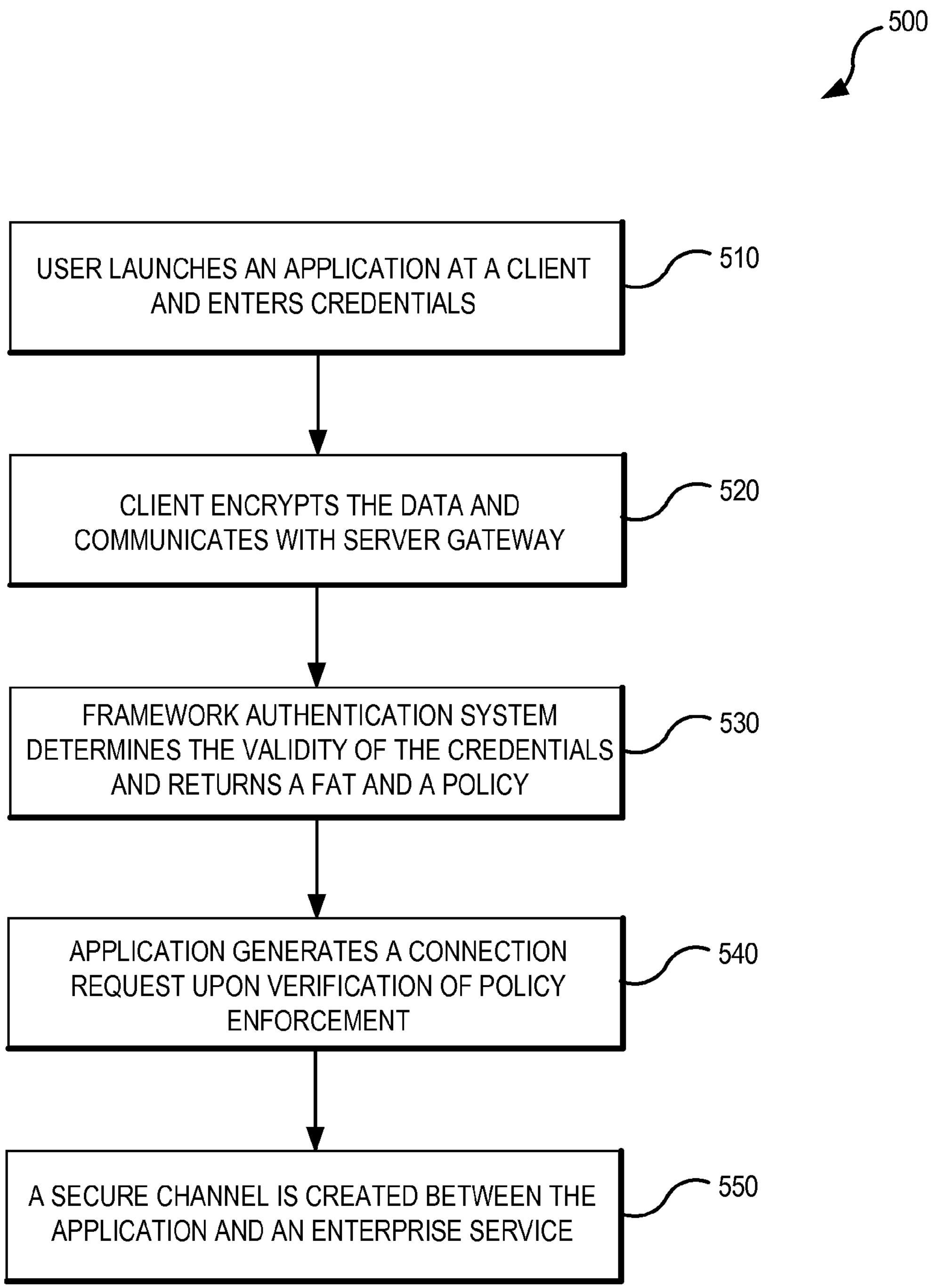
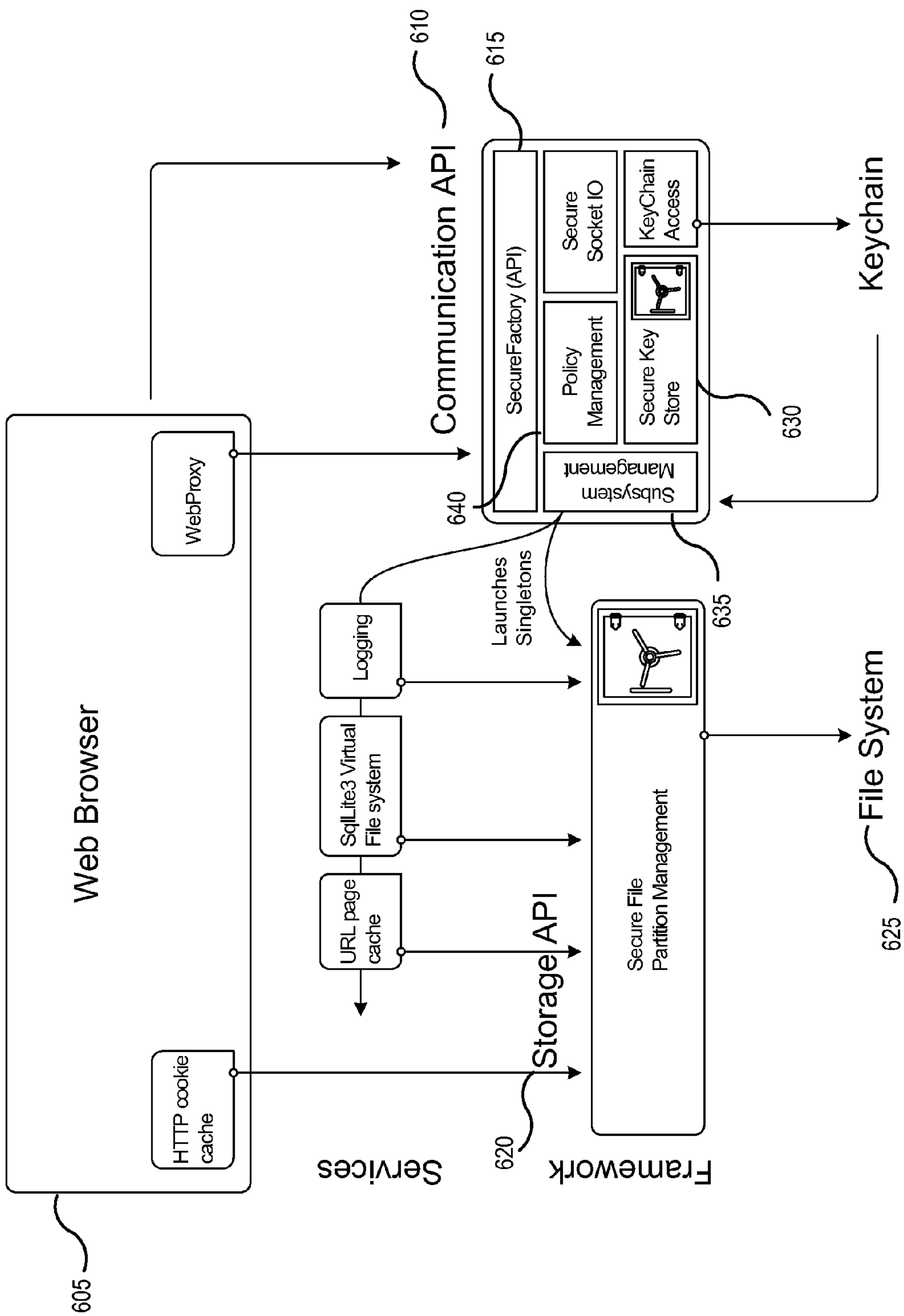

500
USER LAUNCHES AN APPLICATION AT A CLIENT AND ENTERS CREDENTIALS
510
CLIENT ENCRYPTS THE DATA AND COMMUNICATES WITH SERVER GATEWAY
520
FRAMEWORK AUTHENTICATION SYSTEM DETERMINES THE VALIDITY OF THE CREDENTIALS AND RETURNS A FAT AND A POLICY
530
APPLICATION GENERATES A CONNECTION REQUEST UPON VERIFICATION OF POLICY ENFORCEMENT
540
A SECURE CHANNEL IS CREATED BETWEEN THE APPLICATION AND AN ENTERPRISE SERVICE
550

FIG. 5



Web Browser
HTTP cookie cache
WebProxy
URL page cache
SqlLite3 Virtual File system
Logging
Services
Framework
Storage API
Communication API
Launches Singletons
Secure File Partition Management
SecureFactory (API)
Policy Management
Secure Socket IO
Secure Key Store
KeyChain Access
Subsystem Management
Keychain
File System
605
610
615
620
625
630
635
640

FIG. 6

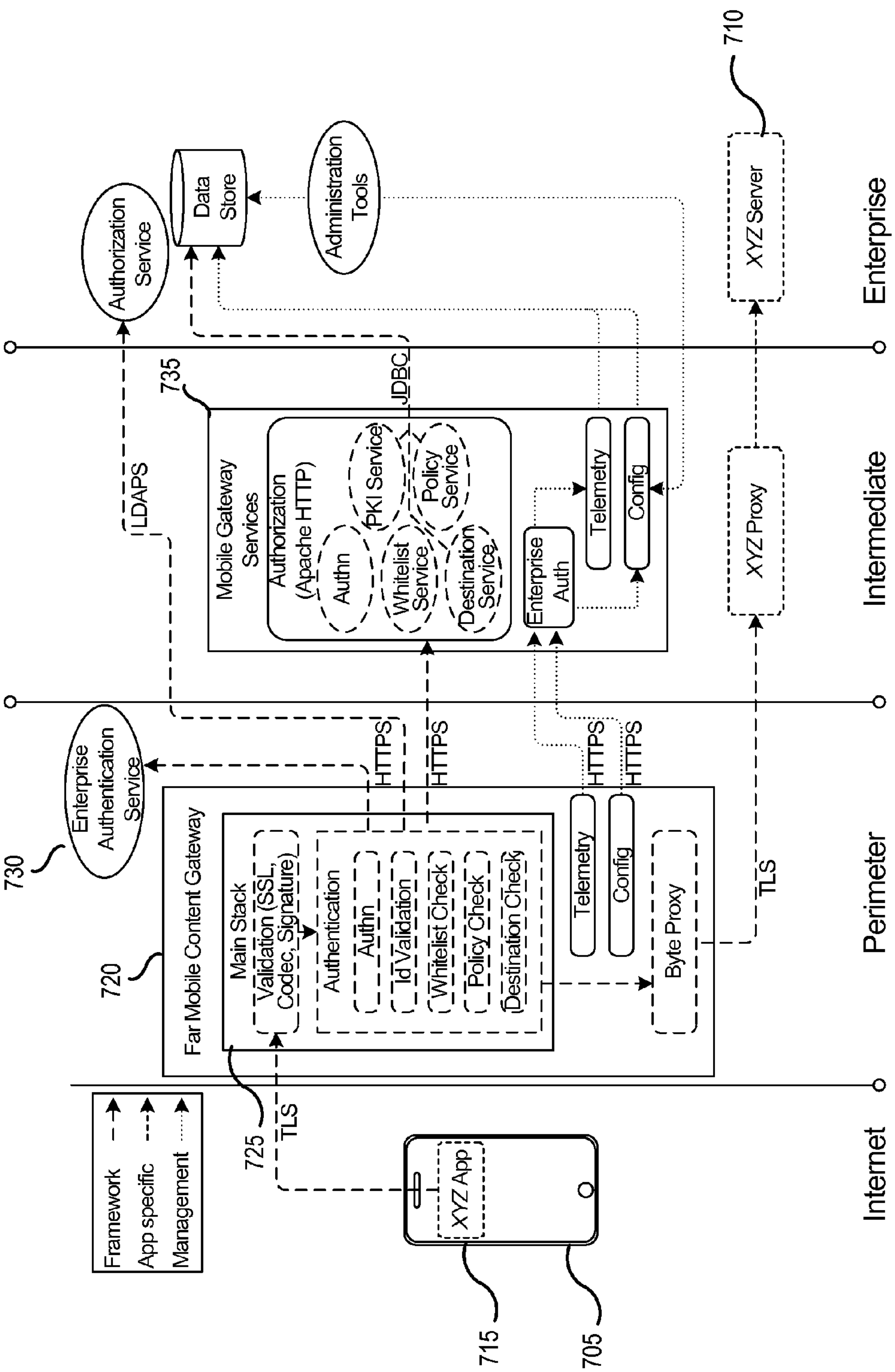
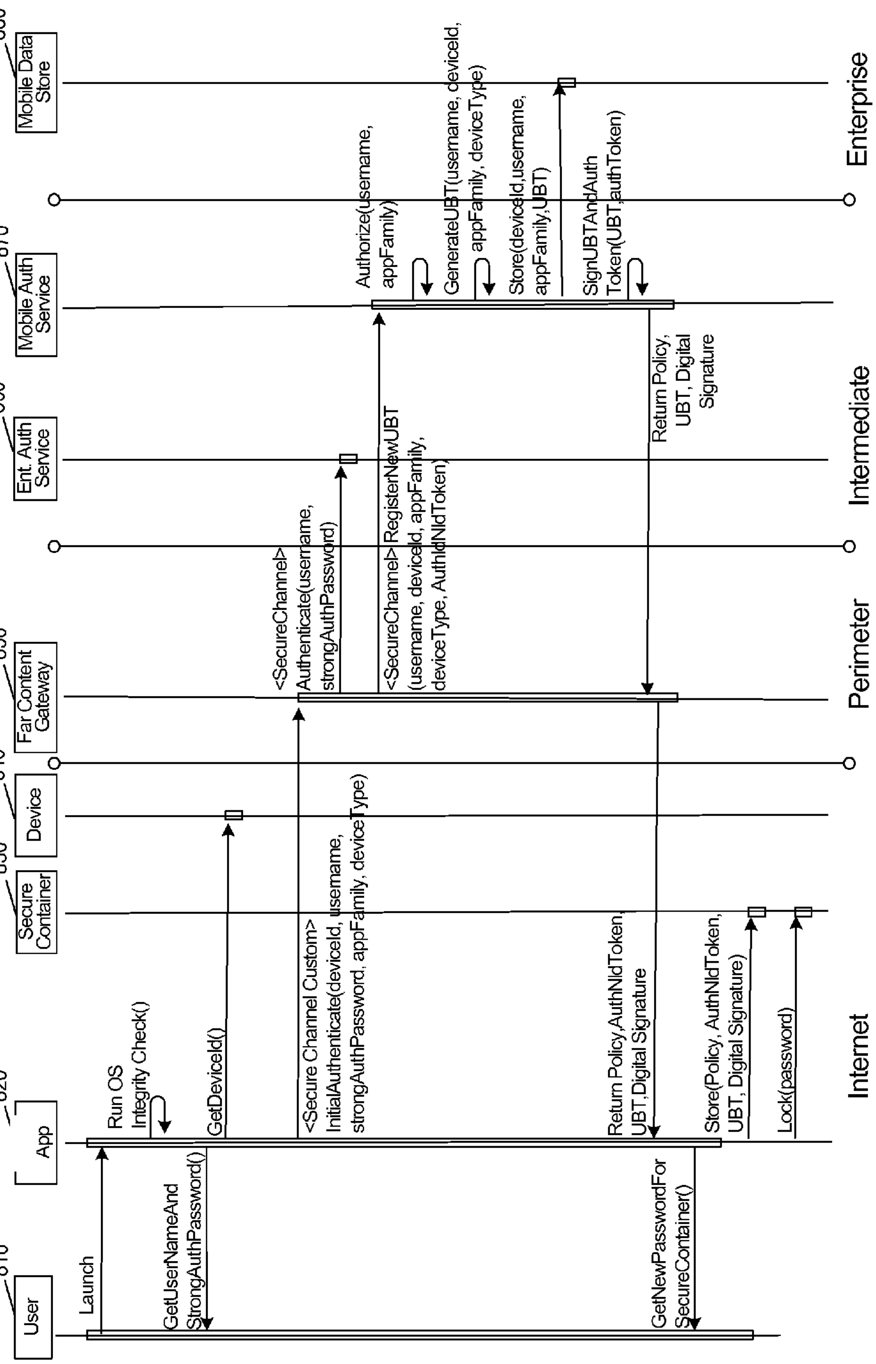
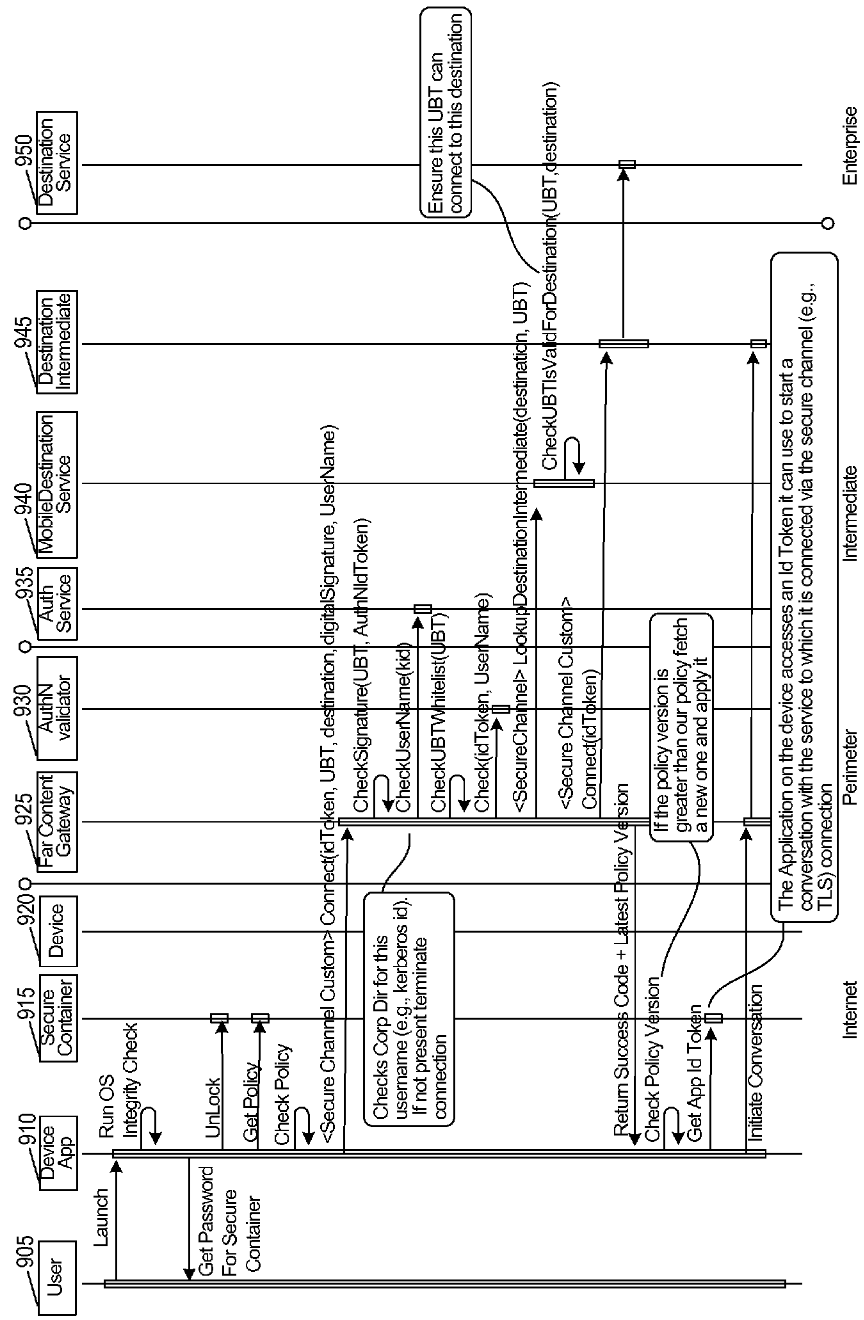

Framework
App specific
Management
Internet
Perimeter
Intermediate
Enterprise
XYZ App
715
705
725
TLS
720
Far Mobile Content Gateway
Main Stack
Validation (SSL, Codec, Signature)
Authentication
Authn
Id Validation
Whitelist Check
Policy Check
Destination Check
Telemetry
Config
Byte Proxy
730
Enterprise Authentication Service
HTTPS
HTTPS
HTTPS
HTTPS
TLS
735
Mobile Gateway Services
Authorization (Apache HTTP)
Authn
PKI Service
Whitelist Service
Policy Service
Destination Service
Enterprise Auth
Telemetry
Config
LDAPS
JDBC
XYZ Proxy
Authorization Service
Data Store
Administration Tools
XYZ Server
710

FIG. 7



810
User
820
App
830
Secure Container
840
Device
850
Far Content Gateway
860
Ent. Auth Service
870
Mobile Auth Service
880
Mobile Data Store
Launch
Run OS Integrity Check()
GetUserNameAnd StrongAuthPassword()
GetDeviceId()
<Secure Channel Custom> InitialAuthenticate(deviceId, username, strongAuthPassword, appFamily, deviceType)
<SecureChannel> Authenticate(username, strongAuthPassword)
<SecureChannel> RegisterNewUBT (username, deviceId, appFamily, deviceType, AuthNIdToken)
Authorize(username, appFamily)
GenerateUBT(username, deviceId, appFamily, deviceType)
Store(deviceId,username, appFamily,UBT)
SignUBTAndAuth Token(UBT,authToken)
Return Policy, UBT, Digital Signature
Return Policy,AuthNIdToken, UBT,Digital Signature
GetNewPasswordFor SecureContainer()
Store(Policy, AuthNIdToken, UBT, Digital Signature)
Lock(password)
Internet
Perimeter
Intermediate
Enterprise

FIG. 8



905 User
910 Device App
915 Secure Container
920 Device
925 Far Content Gateway
930 AuthN validator
935 Auth Service
940 MobileDestination Service
945 Destination Intermediate
950 Destination Service
Launch
Get Password For Secure Container
Run OS
Integrity Check
UnLock
Get Policy
Check Policy
<Secure Channel Custom> Connect(idToken, UBT, destination, digitalSignature, UserName)
CheckSignature(UBT, AuthNIdToken)
CheckUserName(kid)
CheckUBTWhitelist(UBT)
Check(idToken, UserName)
<SecureChannel> LookupDestinationIntermediate(destination, UBT)
CheckUBTIsValidForDestination(UBT,destination)
<Secure Channel Custom> Connect(idToken)
Checks Corp Dir for this username (e.g., kerberos id). If not present terminate connection
Ensure this UBT can connect to this destination
Return Success Code + Latest Policy Version
Check Policy Version
Get App Id Token
Initiate Conversation
If the policy version is greater than our policy fetch a new one and apply it
The Application on the device accesses an Id Token it can use to start a conversation with the service to which it is connected via the secure channel (e.g., TLS) connection
Internet
Perimeter
Intermediate
Enterprise

FIG. 9

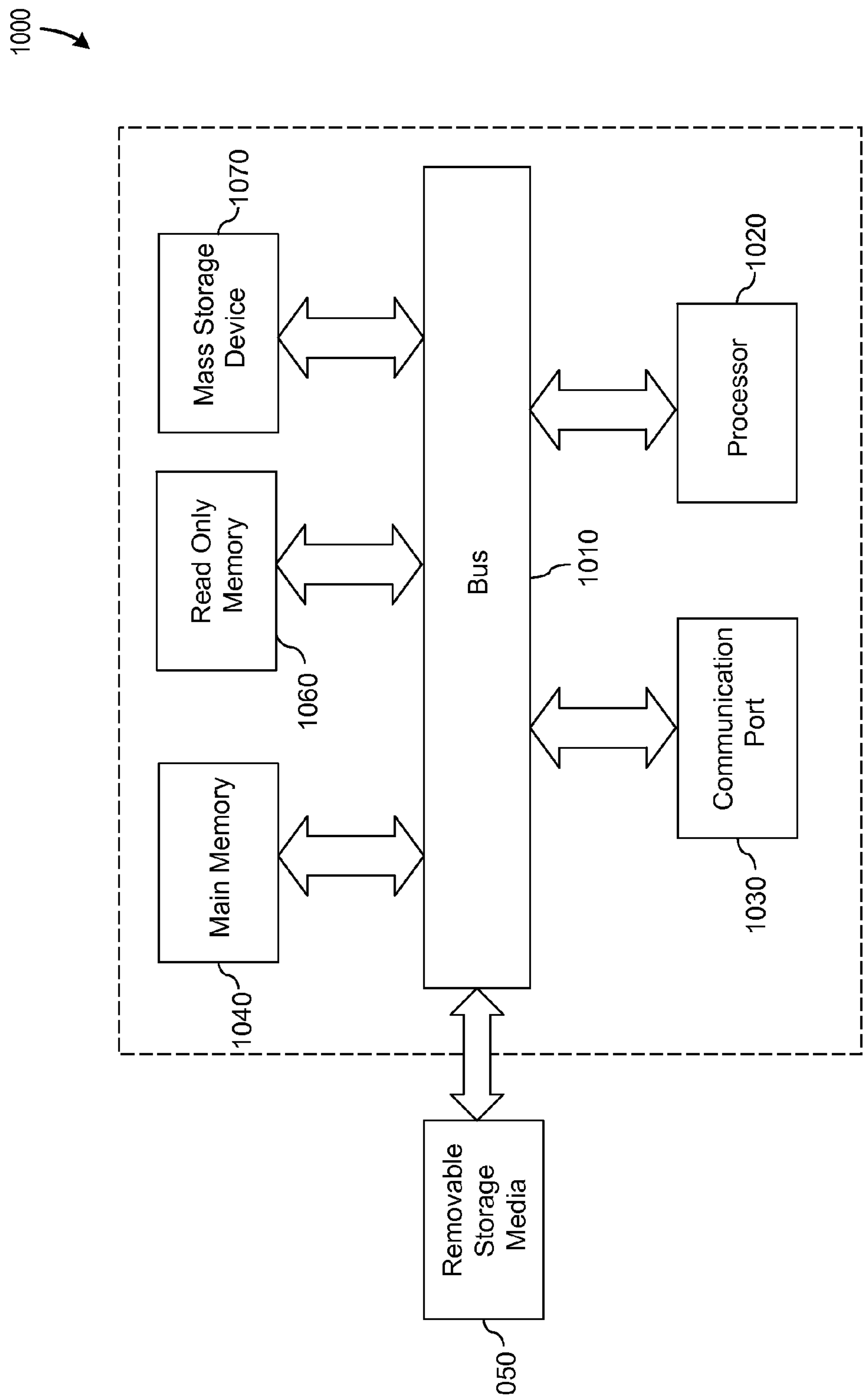

1000
Mass Storage Device
1070
Read Only Memory
1060
Main Memory
1040
Bus
1010
Processor
1020
Communication Port
1030
Removable Storage Media
1050

FIG. 10

SECURE MOBILE FRAMEWORK

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional of U.S. patent application Ser. No. 13/854,837 filed Apr. 1, 2013, which claims priority to U.S. Provisional Application Ser. No. 61/618,511 filed Mar. 30, 2012 and U.S. Provisional Application Ser. No. 61/806,763 filed Mar. 29, 2013. The entire contents of the above applications are incorporated herein by reference for all purposes.

TECHNICAL FIELD

Various embodiments of the present invention generally relate to mobile devices. More specifically, some embodiments of the present invention relate to a secure mobile framework for securely connecting applications running on mobile devices to services within an enterprise.

BACKGROUND

Many companies or enterprises are either providing mobile devices (e.g., smartphones, tablets, etc.) to employees or allowing employees to bring their own mobile device. However, allowing employees to access services within the company through a mobile device has increased the company's exposure to potential security breaches. For example, if an employee lost their mobile device, an unauthorized party could retrieve any unsecured data on the phone and potentially access services within the company. As another example, if the employee leaves the company and does not give back the mobile device, the former employee could still potentially access sensitive data stored on the device or within the company.

In order to mitigate this type of unauthorized access, many companies use mobile device management (MDM) policies to restrict control of the mobile devices and thereby reduce potential security risks for mobile devices that are capable of connecting to services within the enterprise. The MDM policies that are set by the enterprise control and protect data through management of the configuration settings of the mobile devices. In order to manage the configuration settings, over-the-air programming (OTA) capabilities are often used. The use of OTA capabilities allows the enterprise to remotely configure a single mobile device or an entire fleet of mobile devices, to send software and OS updates, and to remotely lock and wipe a device in order to protect the data stored on the device when it is lost or stolen, etc.

However, the restrictions imposed by the MDM polices can be cumbersome to the user who may also be using the device in a personal capacity. For example, an MDM policy may require the mobile device to auto lock and prompt the user to provide a password with a particular set of characteristics before the mobile device is unlocked. The user may find these restrictions annoying. As such, there are a number of challenges and inefficiencies created in traditional mobile device management.

SUMMARY

Systems and methods are described for a secure mobile framework capable of securely connecting applications running on mobile devices to services (e.g., an e-mail service, a trading service, or a reservation service) within an enterprise. In some embodiments, an authentication request from a remote device to access a service provided by an enterprise can be received at a gateway associated with the enterprise. The request can originate from an enterprise managed application running on the remote device. A framework authentication token and security policy (e.g., password structure, password duration, access controls for an application and/or secure container of data, etc.) can be generated.

The security policy can be based on the service provided by the enterprise that the remote device is requesting to access. The framework authentication token and the security policy can then be transmitted to the remote device which ensures compliance with the security policy before generating a connection request to connect to the service within the enterprise. The connection request can be based on the framework authentication token and the security policy. A service authenticator determines if the application running on the remote device is authorized to access the service. Some embodiments monitor interactions between the enterprise managed application and the service. Upon detecting a violation of one or more fraud policies at the mobile device and/or gateway, an elevated authentication request can be generated.

In some embodiments, a request can be received from an initiating device to establish a service connection between an enterprise managed application running on the initiating device and an enterprise service. The request includes authentication credentials associated with an end-user. A framework authentication token can be generated and transmitted to the initiating device, wherein upon receipt the initiating device initiates a service connection request based on the authentication token. A secure connection can be created between the enterprise service and the initiating device upon successful validation (e.g., authorization and authentication) of the service connection request. Any data transmitted to the initiating device using the stored connection can be stored within a secure container that is only accessible by the enterprise managed application.

Embodiments of the present invention also include computer-readable storage media containing sets of instructions to cause one or more processors to perform the methods, variations of the methods, and other operations described herein.

In various embodiments, a system can include a gateway, an authenticator, a token generator, a communications module, a discovery service, and/or a fraud detection module. The gateway can be configured to provide remote devices access to services of an enterprise. In some embodiments, the gateway can include multiple levels, each of which provides isolated authentication protocols and activity logging. The remote devices can have stored thereon one or more applications managed by the enterprise. The authenticator can be configured to determine if a user is authorized to access the enterprise and to construct policies regarding the management of the one or more applications.

The token generator can be configured to generate one or more tokens (e.g., authentication token, a user binding token, and/or a framework authentication token) for creating secure connections between one or more applications managed by the enterprise and servers. The tokens can be based on various identifiers such as, but not limited to the following: user identifier, device identifiers, device type identifiers, application family identifiers, etc. Some tokens may include a binding of other tokens. For example, in one embodiment,

a framework authentication token can be based on an enterprise authentication token, a user binding token, and/or a framework authentication token expiration date. In some embodiments, one or more of the tokens may be cryptographically secured (e.g., digitally signed) that allow for the system to detect if the tokens have been tampered with or altered.

The communications module can be configured to communicate the policies to the remote devices. The discovery service can be configured to determine which of the services of the enterprise to connect with the one or more applications. The anomaly detector can be configured to monitor activity between the remote devices and the servers and generate an indicator of anomalies in activity. For example, the anomaly detector may monitor the IP velocity of the user, failed log-in attempts, etc.

While multiple embodiments are disclosed, still other embodiments of the present invention will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative embodiments of the invention. As will be realized, the invention is capable of modifications in various aspects, all without departing from the scope of the present invention. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will be described and explained through the use of the accompanying drawings in which:

FIG. **1** illustrates an example of a network-based environment in which some embodiments of the present invention may be utilized;

FIG. **2** is a flowchart with a set of exemplary operations for creating a binding between an enterprise managed application and an enterprise service in accordance with one or more embodiments of the present invention;

FIG. **3** illustrates a general architecture for a secure framework which can be used in accordance with various embodiments of the present invention;

FIG. **4** is a flowchart illustrating a set of exemplary operations for authorizing an enterprise managed application in accordance with some embodiments of the present invention;

FIG. **5** is a flowchart illustrating a set of exemplary operations for creating a secure channel between an enterprise service and an enterprise managed application running on a remote device in accordance with one or more embodiments of the present invention;

FIG. **6** is an example of an application built on a secure mobile framework which can be used with various embodiments of the present invention;

FIG. **7** illustrates a remote device accessing a service within an enterprise in accordance with some embodiments of the present invention;

FIG. **8** is a sequence diagram illustrating an initial authentication flow between a device application and an enterprise in accordance with one or more embodiments of the present invention;

FIG. **9** is a sequence diagram illustrating a continuous authentication flow between a device application and an enterprise in accordance with various embodiments of the present invention; and

FIG. **10** illustrates an example of a computer system with which some embodiments of the present invention may be utilized.

The drawings have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be expanded or reduced to help improve the understanding of the embodiments of the present invention. Similarly, some components and/or operations may be separated into different blocks or combined into a single block for the purposes of discussion of some of the embodiments of the present invention. Moreover, while the invention is amenable to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and are described in detail below. The intention, however, is not to limit the invention to the particular embodiments described. On the contrary, the invention is intended to cover all modifications, equivalents, and alternatives falling within the scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION

Various embodiments of the present invention relate generally to a secure mobile framework capable of securely connecting applications running on mobile devices to services within an enterprise. Some examples of services provided by an enterprise include, but are not limited to, an e-mail service, a trading service, a payment processing service, a customer relationship management service, an inventory system service, a business intelligence service, a healthcare service, a student information service, a reservation service, secure services, and/or other services containing sensitive information. In accordance with some embodiments, the secure mobile framework provides a collection of software libraries and service components which provide software developers the ability to build secure applications on non-enterprise mobile devices. The secure mobile framework can be used in conjunction by enterprises that have firewalled content, services, and network from the public network through means of a DMZ type architecture. As a result, much of the enterprise's existing authentication and authorization systems can be utilized. Client and server libraries can be utilized or extended to provide secure storage and communication in both the client and server applications.

There are a number of enterprises which through internal policy or regulation need to ensure that enterprise content and communication is protected, managed and monitored. Normally for devices managed by the enterprise, the aforementioned control requirements are directly implemented through device and operating system (OS) management. However, for devices which are not managed by the enterprise and cannot connect directly to the enterprise network, there is a need to ensure that the same controls are applied to enterprise applications running on these unmanaged devices.

In accordance with various embodiments, the secure mobile framework can provide one or more of the following features to connect and utilize services within the enterprise: 1) mechanisms to store enterprise content on device in a protected manner whereby the enterprise content can only be accessed by authorized users, possibly offline, and be managed through enterprise policy; 2) mechanisms to provide multiple authentications against the gateway (i.e., framework authentication) and against the enterprise services (i.e., enterprise authentication), provide secure connection to those enterprise services where authorized, and manage per service access through enterprise policy; 3) mechanism to manage and support connected applications and their dependent services; and 4) mechanisms to dynamically detect an undesirable or unsafe operating system environment and manage through a multi-step process (e.g., evaluating the policy, interrogation of the program, interrogation of the OS, and/or performing other checks in the client and/or server environments).

The gateway can generate one or more tokens which can be used for authentication. For example, in some embodiments, an enterprise authentication token (EAT) can be generated representing a single or multi-factor credentials that can be used to authenticate with a given company as if single or multi factor credentials were presented, for a finite period of time. A user binding token (UBT) can also be used in one or more embodiments. The UBT can be an amalgamated, unique representation of a user (id), device (id), type of device, and app family. In addition, a framework authentication token (FAT) can be used in various embodiments. The FAT can be created by binding an EAT, UBT, and an expiration date used to authenticate with the framework. One advantage of this construction of the FAT is that the details cannot be tampered with by an unauthorized party.

In some embodiments, secure mobile framework client and server components can be used to detect the integrity of the operational environment for the client application. Given the client application is executing within an unmanaged operating system environment it may need to ascertain, as best it can, if the environment is considered to be unsafe.

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of embodiments of the present invention. It will be apparent, however, to one skilled in the art that embodiments of the present invention may be practiced without some of these specific details.

While, for convenience, embodiments of the present invention are described with reference to dedicated enterprise-based setups, embodiments of the present invention are equally applicable to various other operational models such as cloud-based models. Moreover, the techniques introduced here can be embodied as special-purpose hardware (e.g., circuitry), as programmable circuitry appropriately programmed with software and/or firmware, or as a combination of special-purpose and programmable circuitry. Hence, embodiments may include a machine-readable medium having stored thereon instructions that may be used to program a computer (or other electronic devices) to perform a process. The machine-readable medium may include, but is not limited to, floppy diskettes, optical disks, compact disc read-only memories (CD-ROMs), magneto-optical disks, ROMs, random access memories (RAMs), erasable programmable read-only memories (EPROMs), electrically erasable programmable read-only memories (EEPROMs), application-specific integrated circuits (ASICs), magnetic or optical cards, flash memory, or other type of media/machine-readable medium suitable for storing electronic instructions.

TERMINOLOGY

Brief definitions of terms, abbreviations, and phrases used throughout this application are given below.

The terms "connected" or "coupled" and related terms are used in an operational sense and are not necessarily limited to a direct physical connection or coupling. Thus, for example, two devices may be coupled directly, or via one or more intermediary media or devices. As another example, devices (e.g., mobile devices, server machines, etc.) may be coupled in such a way that information can be passed therebetween, while not sharing any physical connection with one another. Based on the disclosure provided herein, one of ordinary skill in the art will appreciate a variety of ways in which connection or coupling exists in accordance with the aforementioned definition.

The phrases "in some embodiments," "according to some embodiments," "in the embodiments shown," "in other embodiments," and the like generally mean the particular feature, structure, or characteristic following the phrase is included in at least one implementation of the present invention, and may be included in more than one implementation. In addition, such phrases do not necessarily refer to the same embodiments or different embodiments.

If the specification states a component or feature "may", "can", "could", or "might" be included or have a characteristic, that particular component or feature is not required to be included or have the characteristic.

The term "module" refers broadly to a software, hardware, firmware, or service (or any combination thereof) component. Modules are typically functional components that can generate useful data or other output using specified input(s). A module may or may not be self-contained. An application program (also called an "application") may include one or more modules, or a module can include one or more application programs.

General Description

FIG. **1** illustrates an example of a network-based environment **100** in which some embodiments of the present invention may be utilized. As illustrated in FIG. **1**, various enterprise managed applications **110**A-**110**N can be running on user devices **120**A-**120**N. In accordance with various embodiments of the present invention, user devices **120**A-**120**N may or may not be managed by the enterprise. User devices **120**A-**120**N can include enterprise managed applications **110**A-**110**N that can be used to access services and data within the enterprise. User devices **120**A-**120**N may use network **140** to submit and retrieve information from services within the enterprise. User devices **120**A-**120**N can interact with various enterprise services through an application programming interface (API) that runs on the native operating system of the device, such as IOS® or ANDROID™.

Gateway **130** manages the access of enterprise managed applications **110**A-**110**N and user devices **120**A-**120**N. Gateway **130** can be used to verify and establish a trust relationship between the enterprise managed applications **110**A-**110**N and business specific services provided by the enterprise. For example, in some embodiments, the data and requests initially submitted by enterprise managed applications **110**A-**110**N are transferred between the device and gateway **130** via network **140**. Once gateway **130** is satisfied with the security of the device, then gateway **130** can open up a channel to some business specific service within the application management platform **150** and enterprise services **160**. Gateway **130** and services within the application management platform **150** can have multiple independent layers of security and checks.

User devices **120**A-**120**N can be any computing device capable of receiving user input as well as transmitting and/or receiving data via the network **140**. In one embodiment, user devices **120**A-**120**N can be any device having computer functionality, such as a personal digital assistant (PDA), mobile telephone, smartphone, tablet, wearable types of mobile computers, body-mounted computers, or similar device. User devices **120**A-**120**N can be configured to communicate via network **140**, which may comprise any combination of local area and/or wide area networks, using wired and/or wireless communication systems. In one embodiment, network **140** uses standard communications technologies and/or protocols. Thus, network **140** may include links using technologies such as Ethernet, 802.11, worldwide interoperability for microwave access (WiMAX), 3G, 4G, CDMA, digital subscriber line (DSL), etc.

Similarly, the networking protocols used within the various layers of network **140** may include multiprotocol label switching (MPLS), transmission control protocol/Internet protocol (TCP/IP), User Datagram Protocol (UDP), hypertext transport protocol (HTTP), hypertext transport protocol secure (HTTPs), simple mail transfer protocol (SMTP), file transfer protocol (FTP), secure file transfer protocol (SFTP), and/or other networking protocols. Data exchanged over network **140** may be represented using technologies and/or formats including hypertext markup language (HTML) or extensible markup language (XML). In addition, all or some links can be encrypted using conventional encryption technologies such as secure sockets layer (SSL), transport layer security (TLS), and Internet Protocol security (IPsec).

FIG. **2** is a flowchart with a set of exemplary operations **200** for creating a binding between an enterprise managed application and an enterprise service in accordance with one or more embodiments of the present invention. As illustrated in FIG. **2**, installation operation **210** installs an enterprise controlled application on a remote device. The application may be installed by an end-user of the device, an individual from the enterprise, or other source. For example, in some embodiments, the application may be remotely installed or downloaded from an application store. Once the application is installed, authentication operation **220** can prompt a user of the remote device to provide a set of credentials which can be authenticated against the framework. A variety of security protocols and standards (e.g., passwords, passcodes, time-based tokens, encrypted data, auto-lock, etc.) may be used as part of the remote device and application security and authentication processes.

A variety of authentication and security checks are performed at the enterprise during authentication operation **230**. In some embodiments, for example, once the set of credentials are received from the user, an authorization request can be sent from the remote device (i.e., the client) to the gateway server. The gateway server can determine a current policy which should be applied at the remote device and send policy information from the gateway server to the remote device. Then, the device characteristics can be checked and new container credentials can be acquired if necessary. If the gateway determines that the application should have access to one or more servers within the enterprise, creation operation **240** can be used to create a binding between the application and an enterprise service.

FIG. **3** illustrates a general architecture **300** for a secure mobile framework in accordance with various embodiments of the present invention. The secure mobile framework components can be used to manage and protect enterprise content stored on mobile device **305**. In some embodiments, mobile device **305** can include a secure storage **310**, policy **320**, and/or authentication store **325** for mobile application **315**. Mobile application **315** can have a virtual file system that sits under the application. In some embodiments, mobile application **315** can use or generate one or more ephemeral keys, which can have multiple constituent components. The ephemeral keys can be assigned to each partition of the virtual file system to encrypt every file with its own key.

Secure storage **310** can securely store enterprise data locally on mobile device **305**. Secure storage **310** can include a group of protected files managed as single unit through policy **320**. In some embodiments, enterprise content can be stored in encrypted files and accessed via random access methods. In addition, various mechanisms can be used to set encryption block sizes on a per file basis and simultaneously maintain a sidecar index file used to aid with the synchronization content between client and service. The protected files are held within a secure partition which uses a single encrypted master file to hold per file encryption keys and a translation between applications file names and obfuscate file names. This secure file partition mechanism can be used to securitize not only application content directly but also used as a virtual file system for database servers hosted on the device, logging and telemetry data for customer support.

Policy **320** can be an application specific (or application family) security policy set by the enterprise with which application **315** should comply. An application family generally refers to a grouping of applications governed by a common policy that share access to authorization and authentication information on a given device, for a given user. Policy **310** can include the value of security variables used in authorization, authentication, and securitizing data on the device. For example, policy **320** can include password structure, how long the device can remain disconnected from the gateway, how many times the user can fail to enter in a correct password, and other security variables.

A further instance of a secure file partition is authentication store **325** which can contain authentication credentials (e.g., tokens and assertions), policy details, and a master encryption key used to encrypt all other secure file partitions master files. An authentication store master file store can be encrypted with an ephemeral key generated based on a user password or phrase. Furthermore, authentication store **325** can be shared among multiple applications on the device to form a common store for enterprise access and sharing encrypted content.

Once application **315** and corresponding components are installed on mobile device **305**, application **315** can request access to one or more internal services within an enterprise running on servers **330** or virtual machines **335** after passing one or more device security checks. The request from application **315** is first received at a perimeter gateway **340** where a first round of authentication is established before allowing application access to an intermediate layer **345**. Intermediate layer **345** authenticates the user and ensures that the policy being enforced by application **315** is up-to-date. In addition, mobile device telemetry and configuration settings can be gathered, processed, analyzed, evaluated, and/or recorded within database **350**. This information can be useful in creating (e.g., in real-time or in near real-time) various indicators of fraud or anomaly detection. Intermediate layer **345** also allows application **315** to log into mobile application store **350**. In addition, proxy **355** can be used as an intermediary between application **315** and the servers **330**.

FIG. **4** is a flowchart illustrating a set of exemplary operations **400** for authorizing an enterprise managed application in accordance with some embodiments of the present invention. During receiving operation **410**, a request from an enterprise managed application can be received. The request can identify a named service within the enterprise to which the application would like to connect. Initiation operation **420** initiates a secure connection with a perimeter gateway. The perimeter gateway can then ensure the policy operating on the device is up to date using policy verification operation **430** and that the user is still authorized to access enterprise services during user verification operation **440**.

If the policy and user are successfully validated, then validation operation **450** validates the user's authentication credentials at the gateway. Enterprise credentials are then passed to the destination service during submission operation **460** where authentication and authorization take place during verification operation **470**. Upon successful authentication, binding operation **480** creates a binding between the application and the named service.

FIG. **5** is a flowchart illustrating a set of exemplary operations **500** for creating a secure channel between an enterprise service and an enterprise managed application running on a remote device in accordance with one or more embodiments of the present invention. As illustrated in FIG. **5**, the user causes an enterprise managed application running on a client device to launch during launch operation **510**. The application prompts the user for a set of container credentials. Once the credentials are received from the user, the client device uses encryption operation **520** to encrypt the data and communication with a server gateway of the enterprise.

The enterprise managed application can use a framework authentication token (FAT) to authenticate with the gateway, and an enterprise authentication token (EAT) to authenticate with a service. Validation operation **530** determines (e.g., using a framework authentication system) the validity of the FAT. A server authorizer can then construct one or more tokens for creating a secure connection to the enterprise service. For example, in some embodiments the server authorizer can create a User Binding Token (UBT) consisting of the user id, the application id, and the device id. In addition, the FAT can be created by binding the UBT, EAT, and an expiration date. In addition, the server authorizer may determine if the user is authorized to access the enterprise. A secure mobile framework server can construct a policy based on the enterprise services the user can interact with. The information in the policy can include the FAT expiration date, a type of enterprise authentication the user must perform when the FAT expires, and other policy information used to secure data on the mobile device. The secure mobile framework server gateway can then respond to the mobile device with the FAT and the policy.

The calling client (e.g., the mobile device) can use an authentication store to save the FAT and policy content. The application can then use generation operation **540** to generate a connection request upon verification of the policy enforcement. Then creation operation **550** creates a secure channel between the enterprise managed application and the enterprise service. For example, the application can ask the client secure mobile framework to connect to a particular enterprise service using some canonical name. Then, the framework can send the service name along with the UBT to the secure mobile framework server service authenticator over the same connection. The service authenticator determines if the UBT is allowed to connect to that destination.

The secure mobile framework server service router can then map the canonical name to the real address of the service, and establish a connection. The mobile application can now communicate freely over a secured channel once the enterprise authentication is successfully completed. On subsequent requests for connections, the application may ask the secure mobile framework to connect to a particular service using some canonical name. The secure mobile framework can then send the service name along with the UBT and EAT to the secure mobile framework gateway. In some embodiments, the next time the application attempts to connect with the service, this information can be used rather than the user entered enterprise credentials, at least until the FAT expires.

FIG. **6** is an example of an application built on a secure mobile framework which can be used with various embodiments of the present invention. As illustrated in FIG. **6**, web browser **605** represents an implementation of a web browser capable of generating standard HTTP/S requests which may be wrapped in a custom protocol. Web browser **605** can use communications API **610** to establish a connection to the gateway. In some embodiments, communications API **610** can be built on top of secure socket layer (SSL) to access secure factory API **615** for authenticating the user. Typical web based applications require storage of data such as cookies shared with the server and historical URLs. The web browser implementation illustrated in FIG. **6** uses storage API **620** and a secure file partition manager to encrypt data before utilizing the operating system underlying file system **625**

Communications API **610** obtains the user's raw credentials or stored token (FAT) to establish a connection with an enterprise gateway using secure key store **630**. For example, upon receiving the user's credentials, a secure key can be retrieved from secure key store **630**. This key can be used to access a key chain after which subcomponents of the framework can be initialized. System management **635** can receive, from the device/application, an identification of a current policy associated with the application. Using policy management **640** a determination can be made as to whether the policy associated with the application is up to date or needs to be updated. System management **635** can ensure that proper logging, virtual file system management, and page caching occur.

Upon successful authorization and authentication, the gateway requests policy and device information from communications API **610**. Upon successful validation, the gateway can bind a connection to a web browser proxy service, capable of making HTTP/S calls within the enterprise. Web browser **605** can then transmit the wrapped HTTP/S requests through this channel.

FIG. **7** illustrates a remote device **705** accessing a server **710** within an enterprise in accordance with some embodiments of the present invention. As illustrated in FIG. **7**, various embodiments of the present invention allow remote device **705** to access the enterprise through a multi-level authentication process. For example, in order to connect to an endpoint service running on server **710** within an enterprise, a container authentication, a framework authentication, and an enterprise authentication should all be successfully completed in some embodiments. Many traditional authentication systems would require that in order to use an application on a mobile device, a user typically enters a password to unlock the device and then supply a user name and password to authenticate against a remote service. In contrast, various embodiments of the present invention use multiple layers of security before allowing access to data on a device or connections to the remote services.

Upon launching application **715**, a request is sent to far mobile content gateway **720**. Within the main stack **725** of far mobile content gateway **720**, validation and authentication of the user and device can be confirmed. For example, in some embodiments, an enterprise authentication system **730** (e.g., RSA® or Kerberos™) can be used. In some embodiments, the authentication process can include a username, a whitelist check, a policy check, and/or a destination check. In addition, device telemetry and configurations can be monitored and transmitted to a second intermediate authentication layer. These allow for the user, device, and application to be authenticated.

Once the user, device, and application have been authenticated, a connection can be established with server **710**. Many embodiments use the various tokens created during the authentication of the user, device, and application for establishing a connection with server **710**. Far mobile content gateway **720** can connect with mobile gateway services **735** for additional authentication services for access to servers within the enterprise. For example, in some embodiments, a user can enter a password or other authentication credentials within application **715** that can be used to decrypt data stored locally on the device. Then, the user could present a FAT to a gateway process running on a remote environment. The gateway process uses the FAT to authorize and authenticate the user and the device. Then, to access any particular service, the user would present an EAT to the remote service. In some embodiments, the FAT and EAT can be stored locally on the device after preforming one or more pluggable forms of authentication (e.g., time codes+ pin, biometrics, passwords, etc.).

In some embodiments, the form of authentication can be rotated on a predefined schedule (e.g., periodic) or upon detection of one or more events. For example, the gateway can securely transmit the current authentication form to the mobile device which can be stored in the secure store. While FIG. **7** illustrates examples, such as HTTPS and TLS, of secure connections which can be used, other embodiments of the present invention can use different protocols for creating connections for messaging and transferring data between system components.

FIG. **8** is a sequence diagram illustrating an initial authentication flow between a device application and an enterprise in accordance with one or more embodiments of the present invention. As illustrated in FIG. **8**, user **810** launches device application **820**. An integrity detection process is used to determine if the expected OS integrity is present. For example, the integrity detection process can determine if device **840** operating in an elevated unauthorized privilege (e.g., rooting or jailbreak) mode. Device application **820** requests a node identifier (e.g., a Kerberos™ ID) and an authentication password. At which point the device identifier is obtained from device **840**. An initial authentication request can then be submitted (e.g., using a secure connection) to far content gateway **850**. The initial authentication request can include the authentication password, the device identifier, application family, the device type, and/or other information. Far content gateway **850** can then send an authentication request to authentication service **860**. Once authentication service **860** authenticates user **810**, a UBT is registered by mobile authorization service **870**.

Mobile authorization service **870** can authorize access, generate a UBT, and store the device identifier, the user name, application family, and the UBT. Mobile authorization service **870** signs the UBT and authentication token before returning a policy, a UBT, and a digital signature to far content gateway **850**. Far content gateway **850** then generates a FAT which is returned along with the policy, UBT and digital signature to device application **820**. In some cases, the policy may require device application **820** to request a new password for secure container **830**. The FAT, UBT, and digital signature can then be stored in secure container **830** which can be locked with the password.

FIG. **9** is a sequence diagram illustrating a continuous authentication flow between a device application and an enterprise in accordance with various embodiments of the present invention. In the embodiments illustrated in FIG. **9**, user **905** launches device application **910**. An operating system integrity check (e.g., a jail break detection process) can then be used to determine if the integrity of the operating system on device **920** has been compromised. If the operating system integrity check determines that the operating system is not as expected, then device application **910** will not be allowed to connect with gateway **925**. If integrity of the operating system is as expected, device application **910** retrieves the secure container password from user **905** and unlocks secure container **915** to retrieve the current policy. Device application **910** checks the enforcement of the policy and connects to far content gateway **925**. Far content gateway **925** checks the digital signature of the UBT and authentication token. Far content gateway **925** can also submit a user name to authentication service **935**, check a directory to determine the status of the username and if the UBT is on a whitelist, and submit the user name and token to authentication validator **930**.

Device application **910** submits the canonical name of the enterprise service **950** to which the device application wants to connect. Far content gateway **925** uses destination service **940** to determine if the UBT is allowed to connect to that service. If the UBT is allowed to connect, far content gateway **925** binds a connection to the enterprise service **950**, or proxy or intermediate destination **945** to that service **950**. A success code is returned from far content gateway **925** to device application **910** along with the latest policy version. Device application **910** checks to see if the policy version just returned is greater than the policy retrieved form the secure container **915**. If the policy version is greater, then the new policy is applied. The FAT can then be retrieved form secure container **915** and the conversation with far content gateway **925** can be initiated.

Exemplary Computer System Overview

Embodiments of the present invention include various steps and operations, which have been described above. A variety of these steps and operations may be performed by hardware components which are part of a mobile device, server, or other computer system used within embodiments of the present invention. In some embodiments, these steps and operations may be embodied in machine-executable instructions, which may be used to cause a general-purpose or special-purpose processor programmed with the instructions to perform the steps. Alternatively, the steps may be performed by a combination of hardware, software, and/or firmware. As such, FIG. **10** illustrates some components which may be used as part of a computer system **1000** with which embodiments of the present invention may be utilized. As illustrated in FIG. **10**, the computer system may include a bus **1010**, at least one processor **1020**, at least one communication port **1030**, a main memory **1040**, a removable storage media **1050**, a read only memory **1060**, and a mass storage **1070**. In some cases, computer system **1000** may not include any local storage such as removable storage media **1050**, mass storage **1070**, and the like.

Processor(s) **1020** can be any known processor, such as, but not limited to, an Intel® Itanium® or Itanium 2® processor(s); AMD® Opteron® or Athlon MP® processor(s); ARM-based processors; or Motorola® lines of processors. Communication port(s) **1030** can be any of an RS-232 port for use with a modem-based dialup connection, a 10/100 Ethernet port, or a Gigabit port using copper or fiber. Communication port(s) **1030** may be chosen depending on a network such as a Local Area Network (LAN), Wide Area Network (WAN), or any network to which the computer system **1000** connects.

Main memory **1040** can be Random Access Memory (RAM) or any other dynamic storage device(s) commonly known in the art. Read only memory **1060** can be any static storage device(s) such as Programmable Read Only Memory (PROM) chips for storing static information such as instructions for processor **1020**.

Mass storage **1070** can be used to store information and instructions. For example, hard disks such as the Adaptec® family of SCSI drives, an optical disc, an array of disks such as RAID, such as the Adaptec family of RAID drives, or any other mass storage devices may be used.

Bus **1010** communicatively couples processor(s) **1020** with the other memory, storage and communication blocks. Bus **1010** can be a PCI/PCI-X or SCSI based system bus depending on the storage devices used.

Removable storage media **1050** can be any kind of external hard-drives, floppy drives, OMEGA® Zip Drives, Compact Disc—Read Only Memory (CD-ROM), Compact Disc—Re-Writable (CD-RW), and/or Digital Video Disk—Read Only Memory (DVD-ROM).

The components described above are meant to exemplify some types of possibilities. In no way should the aforementioned examples limit the scope of the invention, as they are only exemplary embodiments. Moreover, some of the computer systems (e.g., servers, clients, mobile devices, etc.) contemplated by embodiments of the present invention may not include all of these components. In addition, some of the computer systems may include different configurations and/or additional components from those illustrated in FIG. **10**. For example, some computer systems (e.g., mobile devices) may include a GPS unit and various types of I/O devices (e.g., touchscreens, eye tracking modules, natural language processors, LCD, keyboards, etc.).

In conclusion, the present invention provides novel systems, methods and arrangements for a secure mobile framework for enterprise managed applications. While detailed descriptions of one or more embodiments of the invention have been given above, various alternatives, modifications, and equivalents will be apparent to those skilled in the art without varying from the spirit of the invention. For example, while the embodiments described above refer to particular features, the scope of this invention also includes embodiments having different combinations of features and embodiments that do not include all of the described features.

What is claimed is:

1. A method comprising:

receiving, at a gateway, an authentication request from an initiating device to authenticate an end-user, an enterprise managed application, and the initiating device in order to establish a service connection between the enterprise managed application running on the initiating device and an enterprise service,

wherein the authentication request includes authentication credentials associated with the end-user, a device identifier, and an indication of an application family governed by a common application family security policy such that applications in the application family share access to authorization and authentication information on a given device, for a given user; and

generating a framework authentication token having an expiration date and the common application family security policy, wherein the framework authentication token is generated using an amalgamated, unique representation of the credentials associated with the end-user, the device identifier, the application family, and a device type associated with the device identifier;

transmitting the framework authentication token and the common application family security policy to the initiating device,

wherein upon receipt the initiating device initiates a service connection request based on the framework authentication token and the common application family security policy; and

wherein the service connection request includes a canonical name of the enterprise service;

receiving the service connection request from the initiating device;

mapping, upon successful validation of the service connection request, the canonical name of the enterprise service to an address associated with the enterprise service; and

creating a secure connection between the enterprise service and the initiating device using the address associated with the enterprise service.

2. The method of claim **1**, wherein any data transmitted to the initiating device is stored within a secure container only accessible by the enterprise managed application.

3. The method of claim **1**, further comprising gathering information about the initiating device and the enterprise managed application.

4. The method of claim **1**, further comprising determining a policy that the initiating device should enact in managing the enterprise managed application.

5. The method of claim **4**, wherein the secure connection will not be created if the enterprise cannot verify the initiating device is enacting the policy.

6. The method of claim **1**, further comprising actively monitoring telemetry and configurations of the initiating device.

7. The method of claim **1**, wherein the secure connection has been terminated, and the method further comprising:

receiving, at the gateway, a second service connection request from the initiating device,

wherein the second service connection request includes the framework authentication token;

authenticating the device and end-user using the framework authentication token before establishing a second secure connection between the enterprise service and the initiating device using the address associated with the enterprise service.

8. A non-transitory computer-readable medium containing instructions that when executed by one or more processors cause a machine to:

receive an authentication request from an initiating device to authenticate an end-user, an enterprise managed application, and the initiating device in order to establish a service connection between the enterprise managed application running on the initiating device and an enterprise service,

wherein the authentication request includes authentication credentials associated with the end-user, a device identifier, and an indication of an application family governed by a common application family security policy such that applications in the application family share access to authorization and authentication information on a given device, for a given user;

generate a framework authentication token having an expiration date and the common application family security policy, wherein the framework authentication token is generated using an amalgamated, unique representation of the credentials associated with the end-user, the device identifier, the application family, and a device type associated with the device identifier;

transmit the framework authentication token and the common application family security policy to the initiating device;

receive a service connection request from the initiating device based on the framework authentication token and the common application family security policy,

wherein the service connection request includes a canonical name of the enterprise service;

map, upon successful validation of the service connection request, the canonical name of the enterprise service to an address associated with the enterprise service; and

map, upon successful validation of the service connection request, the canonical name of the enterprise service to an address associated with the enterprise service; and

create a secure connection between the enterprise service and the initiating device using the address associated with the enterprise service.

9. The non-transitory computer-readable medium of claim **8**, wherein any data transmitted to the initiating device is stored within a secure container only accessible by the enterprise managed application.

10. The non-transitory computer-readable medium of claim **8**, wherein the instructions that when executed by the one or more processors further cause the machine to gather information about the initiating device and the enterprise managed application.

11. The non-transitory computer-readable medium of claim **8**, wherein the instructions that when executed by the one or more processors further cause the machine to determine a policy that the initiating device should enact in managing the enterprise managed application.

12. The non-transitory computer-readable medium of claim **11**, wherein the secure connection will not be created if the enterprise cannot verify the initiating device is enacting the policy.

13. The non-transitory computer-readable medium of claim **8**, wherein the instructions that when executed by the one or more processors further cause the machine to actively monitoring telemetry and configurations of the initiating device.

14. The non-transitory computer-readable medium of claim **8**, wherein the secure connection has been terminated, and the instructions that when executed by the one or more processors further cause the machine to:

receive a second service connection request from the initiating device,

wherein the second service connection request includes the framework authentication token;

authenticate the device and end-user using the framework authentication token before establishing a second secure connection between the enterprise service and the initiating device using the address associated with the enterprise service.

15. A system comprising:

means for receiving an authentication request from an initiating device to authenticate an end-user, an enterprise managed application, and the initiating device in order to establish a service connection between the enterprise managed application running on the initiating device and an enterprise service,

wherein the authentication request includes authentication credentials associated with the end-user, a device identifier, and an indication of an application family governed by a common application family security policy such that applications in the application family share access to authorization and authentication information on a given device, for a given user;

means for generating a framework authentication token having an expiration date and the common application family security policy, wherein the framework authentication token is generated using an amalgamated, unique representation of the credentials associated with the end-user, the device identifier, the application family, and a device type associated with the device identifier;

means for transmitting the framework authentication token and the common application family security policy to the initiating device;

means for receiving a service connection request from the initiating device based on the framework authentication token and the common application family security policy,

wherein the service connection request includes a canonical name of the enterprise service;

means for mapping, upon successful validation of the service connection request, the canonical name of the enterprise service to an address associated with the enterprise service; and

means for creating a secure connection between the enterprise service and the initiating device using the address associated with the enterprise service.

16. The system of claim **15**, wherein any data transmitted to the initiating device is stored within a secure container only accessible by the enterprise managed application.

17. The system of claim **15**, further comprising a means for gathering information about the initiating device and the enterprise managed application.

18. The system of claim **15**, further comprising a means for determining a policy that the initiating device should enact in managing the enterprise managed application.

19. The system of claim **18**, wherein the secure connection will not be created if the enterprise cannot verify the initiating device is enacting the policy.

20. The system of claim **15**, further comprising actively monitoring telemetry and configurations of the initiating device.

21. The method of claim **1**, wherein the secure connection is a secure channel such that the initiating device can communicate freely with the enterprise service.

22. The non-transitory computer-readable medium of claim **8**, wherein the secure connection is a secure channel such that the initiating device can communicate freely with the enterprise service.

23. The system of claim **15**, wherein the secure connection is a secure channel such that the initiating device can communicate freely with the enterprise service.

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